20. The mold of claim 19, wherein the central rib includes a circumferential depression centered on the equatorial plane of the mold.

21. The mold of claim 20, wherein a ratio of height of the central rib, with respect to the radial interior surface, and depth of the circumferential depression is included between 1.75 and 6.5.--

A1

IN THE DRAWINGS:

Subject to the approval of the Examiner, please amend the drawings as shown in red on the attached Request For Approval Of Drawing Change. Specifically, Fig. 3 has been amended by adding the legend --Prior Art--.

REMARKS

Prior to the examination of the above-identified application, please enter this Preliminary Amendment. By this Preliminary Amendment, Applicant has entered a substitute specification pursuant to 37 C.F.R. § 1.125. The substitute specification, which includes a new title and abstract, contains no new matter. As required by Rule 1.125, Applicant has enclosed herewith a clean version of the substitute specification along with a marked-up version of the substitute specification showing the material both added to and deleted from the original specification.

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If there is any fee due in connection with the filing of this Preliminary Amendment, please charge the fee to our Deposit Account No. 06-0916.

Respectfully submitted,

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Dated: September 25, 2001

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MARKED-UP SUBSTITUTE SPECIFICATION

MOLD FOR VULCANIZING A TIRE HAVING A SPECIFIED BELT PROFILE IN THE ABSENCE OF LOAD AND INFLATING PRESSURE

This is a division of application Serial No. 08/951,672, filed October 16, 1997, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention [IMPROVED-PERFORMANCE TYRE AND RELATED MANUFACTURING METHOD AND MOULD]

The present invention relates to a high-performance [tyre, in particular in connection with] tire, which mitigates the aquaplaning effect and increases wear-resistance, as well as to the manufacturing method and [mould] mold thereof.

More particularly, the [tyre] tire of the invention is of the type comprising a tread band provided with at least one large-sized, extended circumferential cavity, preferably but not exclusively disposed at a central position, [which is of large sizes for the purpose of fast ejection of all] for quickly ejecting water collected on the ground so as to counteract the effect currently referred to as "aquaplaning"[which consists in losing]. Aquaplaning occurs when a vehicle loses ground contact [by the vehicle, in particular], particularly at high speed, due to the continuous water film interposed between the [tyre] tire and the ground.

[Tyres] Tires of the above type, in which the tread substantially comprises two distinct axial portions separated from each other by a wide circumferentially-extended cavity [have already been on the market since long], are well-known and have been described in [many] several patents briefly mentioned hereinafter [for the purpose of summarizing the hitherto known state of the art.].

Description of the Related Art

For instance, patent EP 0 503 404 discloses a tread comprising circumferential and transverse S-shaped grooves, crossed with each other so as to form a plurality of blocks, and provided with a central cavity of a width corresponding to 10%-20% of the tread width and a depth corresponding to 78%-80% of the overall tread thickness.

Patent EP 0 503 405, in addition to the above, gives particular values for the angle of inclination of the entrance and exit walls of the blocks [relatively] relative to the ground-contacting area[, and patent]. Patent EP 0 503 406 also illustrates particular connecting arcs of the side walls of the different tread band blocks.
Other details concerning the geometrical and operating features of the grooves and blocks in the tread pattern are described in US patent Nos. 5,176,766; 4,700,762; and 4,785,863.

US Patent 4,796,683 refers to a tread pattern comprising a circumferentially-directed cavity and transverse grooves of great inclination to the cavity so as to promote water draining. In this tread pattern blocks are formed that have acute and obtuse angles. Close to the acute angles where stiffness is lower, the greatest abrasion can be found. Elimination of this drawback is suggested by forming particular chamfers in the blocks so as to increase the block stiffness at aimed areas.

US patent 4,289,182 refers to a [motor cycle tyre] motorcycle tire adapted for high speed and provided with a tread pattern having a circumferentially-directed cavity and two sets of rectilinear transverse grooves at each side of the cavity. Between the grooves of the two sets, a zigzag rib is formed.

The Applicant has noticed that the known [tyres] tires of the above type generally exhibit a marked wear of the tread band at the central area thereof, close to the cavity along the equatorial plane, which takes place early and [goes on in time, giving rise to a quicker reduction in the lifetime of the tyre as compared with a] continues over time. The remaining tread portions outside of the central area exhibit slower wear, and therefore, the overall lifetime of the tire is

reduced as compared to possible lifetime of [the same tyre resulting from the slower wear of the remaining tread portions.] an evenly wearing tire.

It is a current hypothesis that this type of wear depends on a greater flexibility and deformability of the carcass by effect of the wide central cavity in the tread pattern.

US Patent 4,687,037, [concerning a tyre comprised of] directed to a tire comprising a carcass, a belt and a tread band having a circumferential cavity in the middle, the width of which corresponds to 20% of the tread width, attempts to find a solution to this problem by imparting a particular rigidity to the belt. Actually the belt comprises a plurality of reinforcing layers having cords crossed with each other following known techniques, partly substantially extended over the whole width of the tread band, and partly axially concentrated on given preferential areas.

In particular, the belt structure has four layers of mutually crossed cords of a width corresponding to the tread band width and two further reinforcing layers of a width as large as or slightly larger than the width of the central cavity. These further layers of reduced width are disposed below the cavity, the first layer between the two pairs of layers of a width as large as that of the tread band and the second layer immediately under the cavity, respectively.

Radially projecting outwardly from the cavity bottom, in such a manner as to nearly constitute a link between the two distinct tread band portions, there is a rib of elastomeric material extending over the whole cavity length.

SUMMARY OF THE INVENTION

The Applicant [has intuitively understood] believes that the known solutions [were] are not capable of [solving] providing an adequate solution to the problem because [they started from a wrong perception of same and therefore they faced it in an inappropriate manner] each is based on an incorrect perception. In particular, in accordance with the invention, it has been understood

that said early and localized wear depended on the anomalous expansion of the belt at the central cavity, [which] where this expansion was made possible by the reduced structural strength of the tread due to a lack of material at this [very] area.

This expansion was not sufficiently inhibited by the addition of new belt layers because all layers are fairly expandible in a circumferential direction due to a rotation of the reinforcing cords in the lying plane of the cords themselves and due to the typical elasticity [typical] of the rubberizing material forming [said] the layers.

[Still in] In accordance with the present invention, the [Applicant's proposal] Applicant proposes to solve the problem [is that of] by trying to achieve [the] reinforcing-belt stability in the area [where the] of thinner tread below the cavity [is of reduced thickness by] and exerting a control on [said] the anomalous belt expansion[, so as to make a tyre in which the tread band is of improved performance in terms of wear and therefore]. The resulting tire has a better performing tread band in terms of wear, and therefore the tire has a longer lifetime.

Accordingly, [in] a first aspect the invention relates to a [tyre] tire for motor-vehicle wheels comprising a [toric] toroidal carcass provided with axially opposite sidewalls and beads for anchoring [of said tyre] the tire to a corresponding mounting rim, a tread band disposed crown-wise to said carcass and a belt structure interposed between said carcass and said tread band, axially extended in a continuous manner between [said] the sidewalls, said tread band being [moulded] molded with a raised pattern having at least one circumferential groove, characterized in that, in a non-operating condition, that is in the absence of load and inflating pressure, said belt structure, seen in right section in the plane containing the [tyre] tire axis, has an axial profile comprising three distinct portions, two side portions and one central portion respectively, said central portion being interposed between said side portions [in register with said circumferential groove], said side portions being concave at a radially internal position, in which the concavity is defined for each portion by a respective [centre] center and a respective

radius of curvature, said central portion being concave at a radially external position, [in which the depth of said] the concavity center of the central portion lying in the center line plane of the circumferential groove, in which the depth, S, of the outer concavity is capable of being [cancelled] canceled under the effect of the normal inflating pressure of the [tyre] tire.

In a convenient embodiment of the invention, the [concavity centre of said central portion lies in the centre] center line plane of said groove [which] is coincident with the equatorial plane of the [tyre] tire.

Preferably in this case the depth S of said concavity is defined by the relation:

$$S = R_l - R_0$$

wherein:

- R_l corresponds to the radius of a known [tyre,] tire as measured at the equatorial plane when the tire is mounted to the respective rim and inflated to the normal running pressure. This tire is identical in its structure and size to the tire of the present invention [with said tyre,] except for the fact that its belt structure under any condition and seen in right section [ ]exhibits a continuously concave profile in a radially internal position[, measured at the equatorial plane when the tyre is mounted to the respective rim and inflated to the normal running pressure];

- R_0 corresponds to the radius of the same known [tyre] tire, still measured at the equatorial plane,

[on the tyre] under non-working conditions.

Therefore, the depth S of the concavity of the central portion is precisely the depth required to negate the expanding effect at the equatorial plane exhibited by known tires. Upon inflation of the tire of the present invention, the concavity of the central portion of Applicant's tire having a depth S is reversed to yield a profile substantially corresponding to a profile of the prior art tire under non-inflated conditions.

In a preferred embodiment, said circumferential groove comprises, in combination with the underlying belt concavity, reinforcing means of said tread band, preferably disposed in a central position relative to said groove, radially projecting from the bottom; still more preferably these means comprise a continuous circumferential rib, disposed at the [centre] center line plane of the groove, extended radially outwardly in cantilevered fashion from the groove bottom.

Conveniently, the ratio of the rib height to the groove depth along the [centre] center line plane is included between 0.2 and 0.5.

[It is to point out that the larger the sizes of said groove are and the lower] The performance of the invention improves as the size of the groove increases and as the thickness of the elastomeric material [is at said groove, the more the invention performs its advantageous effects: therefore] at the groove decreases. Therefore, preferably the thickness of said tread band at the [centre] center line plane of the groove is included between 1 and 3.5 mm, and the ratio [value] of the groove depth to the thickness of the underlying portion of the band [being included] is between [2.5] 2.0 and 10.

[In another] Another aspect the invention [also] relates to a process for manufacturing a [tyre] tire comprising a [toric] toroidal carcass provided with axially opposite sidewalls and beads for anchoring [of] said [tyre] tire to a corresponding mounting rim, a tread band disposed crown-wise to said carcass and a belt structure interposed between said carcass and tread band, axially extending in a continuous manner between said sidewalls, said tread band being [moulded] molded with a raised pattern provided with at least one circumferential groove, said process comprising the step of disposing the green [tyre,] tire, in a [toric] toroidal conformation, in a vulcanization [mould for achievement of] mold to achieve its final [moulding] molding configuration by means of a heat treatment at high temperature and with the use of fluid under pressure, characterized by utilizing a [mould] mold forcing said belt structure to take a

[moulding] molding configuration the profile of which, seen in right section in the plane containing the [tyre] tire axis, comprises three distinct portions, i.e. two side portions, respectively referred to as first and second portions, and one third portion, the central one, interposed between said side portions in register with said circumferential groove, said side portions being concave in a radially internal position, in which the concavity is defined for each portion by a respective [centre] center and a respective radius of curvature, said central portion being concave in a radially external position, the depth of said radially external portion being capable of being [cancelled] canceled under the effect of the normal inflating pressure of the [tyre] tire.

In still another aspect, the invention relates to a [mould] mold for [tyre] tire vulcanization, comprising axially opposite sidewalls and a tread band [moulded] molded with a raised pattern formed with at least one circumferential groove, said [mould] mold comprising a pair of axially opposite cheeks corresponding to the sidewalls of said [tyre] tire and a matrix interposed between said cheeks, corresponding to said tread band, said matrix being provided with a plurality of ribs projecting in a raised configuration from a bottom surface for forming said pattern, characterized in that, in a plane containing the [mould] mold axis, the sectional profile of said bottom surface comprises two distinct concave side portions, in which the concavity is defined for each portion by a respective [centre] center and a respective radius of curvature, and the sectional profile of the surface tangent to the ridge of said ribs in the area included between said side portions has a convexity directed radially inwardly.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood with the aid of the following description and the accompanying drawings exclusively given by way of non-limiting example, in which:

- Fig. 1 shows an axial right section of the profile of a [tyre] tire in accordance with the invention in a use condition, that is mounted to the corresponding mounting rim (not shown) and inflated to the rated work pressure, in the absence of load;

- Fig. 2 shows, with the same references as in fig. 1, the profile of the [tyre] tire in accordance with
the invention under two different conditions, i.e. a non-operating condition in solid line and a use condition in chain line, respectively;
- Fig. 3 shows the profile of a known [tyre] tire in the crown portion alone, under the same conditions as in Fig. 2, i.e. a non-operating condition in solid line and a use condition in chain line, respectively;
- Fig. 4 is a diagrammatic and partial profile in right section of the [tyre] tire belt in accordance with the invention, under the two different conditions shown in Fig. 2;
- Fig. 5 is a view in right section of a rib in the circumferential groove of the [tyre] tire tread band in
accordance with the invention;
- Fig. 6 is a partial view of a preferred tread pattern in the [tyre] tire of the invention;
- Fig. 7 is an axial right section of the profile of a [mould] mold for manufacturing a [tyre] tire of known
type (in solid line), the profile of a [mould] mold for manufacturing a [tyre] tire in accordance with the
invention (in dotted line), and the profile of the surface tangent to the rib ridges in the [mould] mold
in accordance with the invention (in chain line).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a generic [tyre] tire structure, which is common both to the [tyre] tire of known type and to the [tyre] tire in accordance with the invention: the differences between the [tyres] tires and [as regards] the [
]respective manufacturing methods will be illustrated in detail in the [progress of the present] following description.

[Tyre] Tire 1 comprises a carcass 2 of a strong structure formed of at least one ply 3 of rubberized fabric, the ends of which are each turned up about an anchoring core 4, which is provided with a rubber filling 5 on its radially outer surface. Preferably the turned-up flaps 3' of the carcass ply extend radially outwardly along at least part of the side of said filling.

As known, the [tyre] tire area comprising the anchoring core 4 and filling 5 forms the [tyre] tire bead intended for anchoring the [tyre] tire to a corresponding mounting rim (not shown).

Disposed on the carcass in known manner is a tread band 10 provided with a raised pattern and designed for carrying out the rolling contact of the [tyre] tire with the ground.

The tread pattern may comprise a plurality of ribs and/or blocks separated from each other by corresponding grooves directed both circumferentially and transversely, said ribs and/or blocks being optionally provided with different cuts and fins or lamellae[, all that following]. These components of the tread pattern may follow configurations well known to those skilled in the art.

[Tyre] Tire 1 further comprises a belt structure 6 disposed crown-wise to carcass 2, interposed between the carcass and tread band, substantially extending from one [tyre] tire sidewall to the other[, that]. The belt structure is as wide as the tread band, and [comprising] it comprises two radially superposed layers 7, 8 of preferably metallic reinforcing cords, parallel to each other in each layer and crossed with those of the adjacent layer with respect to the equatorial plane of the [tyre, and a radially] tire. Radially outermost layer 9 of reinforcing cords, preferably of textile material and more preferentially of a heat-shrinkable material (e.g. nylon) oriented at substantially 0', [that is] extends in a circumferential direction.

For the sake of simplicity, and for better understanding the invention, Fig. [1I] 1 shows a [tyre the] tire having a tread band [of which] that comprises one circumferential groove or cavity 11 alone[, the centre]. The center line plane of [which] the tread band is coincident with the

equatorial plane of the [tyre,] tire, and [in which] the different blocks and [further] grooves that may be present on [said] the tread band are omitted.

The main function of groove 11 is that of collecting and ejecting [the] water which stays between the [tyre] tire and the ground while the [tyre] tire is running on a wet road.

[Said groove] Groove 11 is a means well known to those skilled in the art for [ensuring to] providing a high-performance [tyre] tire having particular [tread patterns, an] excellent resistance to the aquaplaning [
]effect [concurrently with] as well as other desirable features, some of which are in themselves negative towards [said] aquaplaning resistance.

Unfortunately, as [already said] described in the [part describing] discussion of the [known] prior art, [tyres] tires of this type are subjected to a quick and continuous, irregular wear of the tread band[, which]. This wear is concentrated on the area on either side of the circumferential groove.

In accordance with the invention, the Applicant has [intuitively] understood that such an irregular wear, [of] impossible [elimination] to eliminate with the usual expedients of the known art, could depend on a deviation of the radially external profile of the tread band from the design value[, and that this deviation was very likely to be maintained in time and restored when it was hindered by interventions on the structural elements of the tyre aiming at making attempts to eliminate the (visible) effects of this (unknown) deviation.].

[Actually, the tyre] The tire cross section (see Fig. 1) has a wide axial area[, at the groove, where there is a very reduced thickness of the material (in relation to the thicknesses of the band on the groove sides)] at the groove. In this area, residing between the groove bottom and the belt[, that is in] and providing the underlying cushion, the tread band material is much thinner than the material of the band on the groove sides. .[.]

[Practically, due] Due to the reduced amount of material at the groove, this tread area, extending along the entire circumferential distance of the tire, has a reduced resistance to deformation[, along the whole circumferential extension of the tyre, so that]. As a result, the corresponding belt portion, due to the thrust action of the inflating pressure, tends to expand to a greater degree than the side portions[, thereby pushing]. Thus, the groove edges and the [immediately close] adjacent tread band portions[,] are pushed outwardly so that they take a profile radially more external than the [previously calculated one, that is the] design profile.

This phenomenon and the advantageous results achieved by the invention are shown in Figs. 2 and 3. In these figures and in the following ones the belt structure is graphically shown by a single line 6.

Shown in Fig. 2 in solid line is the profile (P_1) of a [tyre] tire in accordance with the invention [in its moulding configuration, that is] after extraction from the vulcanization [mould,] mold and under deflated conditions[, and in]. The chain line depicts the profile (P_2) [Of] of the tire in its final or use configuration[, that is] after it has been mounted to [the] a corresponding rim and inflated to the work pressure, in the absence of load.

Fig. 3, showing the crown portion of a known [tyre only,] tire, highlights[,] in solid line, the external profile (P_3) of the tread band and the profile (N) of the underlying belt 6 for the [tyre] tire in a deflated condition[, and in chain line, the]. The corresponding profiles (P_5) and (P_6) under use conditions[,] and in the absence of load [; from] are shown by the chain line. From a comparison one can clearly see the particular expansion of the tread [to which the known tyre is submitted under a work condition,] at the area about the circumferential groove 11 to which the known tire is submitted under working conditions. The deviation between the two profiles [can concern] is apparent over the whole width of the tread band; in particular [on the tyre shoulders], as seen at the tire shoulder area, profile P_5 may be radially internal to profile P_3.

Fig. 3 [enables now to easily understand] depicts not only the cause of [this] the uneven wear, but also why [this] the cause is not eliminated by the known solutions of the state of the art[: it is to note that profile P3 substantially corresponds to profile P2- In other words, as]. As the elastomeric material portion included between profile P_5 and profile P_3 (Fig. 3) is abraded, new material is exposed to abrasion due to the belt expansion caused by the inflating pressure and [also promoted by] due to the progressive [thickness reduction] thinning of the tread band [at] material in this area.

Fig. 2 [already enables to intuitively understand] depicts the fundamental feature of the invention, [consisting] which consists of a [tyre] tire structure that [on] upon passing from a deflated [tyre] state to an inflated [tyre modifies the] state possesses a modified radially external tread band profile of the tread band[, keeping it]. This modification of the external tread band profile ensures that the final profile under inflated conditions is within the predetermined design limits, even in the presence of [important] localized variations in the thicknesses of [said band.] the tread band.

[In particular, Fig. 2 also shows an easy manner for distinguishing the inventive tyre from similar tyres of the known art without resorting to complicated and sometimes destructive examinations but merely with the aid of surveys of geometrical character carried out on the vulcanized tyre.

Practically, under] Under non operating conditions, and more particularly in its [moulding] molding condition, the inventive [tyre] tire exhibits two distinct circumferential sections a-a and b-b[,] of maximum diameter[, one for each]. Each section is located in a respective tread half[, substantially] at the divergence points between the [above mentioned] profiles $P_{1[,]}$ and P_2[, the]. The intermediate sections between these two sections [being] a-a and b-b are of lower diameter.

[In the tyre in use]Under use conditions, these two sections a-a and b-b converge on the equatorial plane X-X where [however], due to the presence of the central groove, the diameter can be [hardly measured but is of easy determination] determined by extrapolation of the tread profile in axial right section.

In the prior art, [tyres have been already known which under deflation conditions] tires are known that show two distinct circumferential sections of maximum diameter[, but these] under deflation conditions. These sections, though, due to the presence of a belt structure of a quite traditional type, [keep] remain substantially unchanged even when the [tyre] tire is in its use [conditions. Disappearance] condition. In contrast, disappearance of these two distinct sections [from the inflated tyre is a clear sign that the tyre under examination is likely to be a tyre] once the tire is inflated indicates that the tire is one in accordance with the [invention.] present invention.

[Substantially, the tyre of the invention]As shown in Fig. 4, the tire of the present invention has a particular belt structure configuration when coming out of the [mould has a particular configuration as regards its belt structure, better shown in Fig. 4, with which] mold. In this configuration, the tread profile and the profile of the underlying carcass ply match. [

]More particularly, the [tyre] tire belt 6 of the invention (Fig. 4) under deflated conditions, has a configuration (shown in solid line) comprising three distinct portions, respectively referred to as first (14) and second (15) portions, disposed laterally of the groove 11, and third portion (16) in the middle, at an intermediate position between the first and second portions.

The side portions 14 and 15 are outwardly convex and are each identified by a respective radius of curvature, r_1 and r_2, preferably of having substantially identical size length each other, and by respective distinct [centres] centers of curvature.

The central portion 16 is outwardly concave and is identified by a different radius of curvature r_3, the [centre] center of which in [the] this case [herein shown] lies in the equatorial plane.

Highlighted on the belt profile are points A and B at which reversal of the profile curvature occurs[: these]. These points may [substantially] be in correspondence with the [groove 11 edges, or they may not be coincident therewith and preferentially may be axially external thereto.] edges of groove 11. Alternately, and preferably, points A and B are not coincident with the edges of groove 11 and lie axially external to the edges of groove 11.

[Substantially, as can be viewed from Fig. 2, on coming out of the mould the tyre of the invention,] ~~As shown in Fig. 2, upon release from the mold, the tire of the present invention~~ exhibits a diametrical reduction at the central portion [where there is the groove comprises a profile] of the tread band [and]. As a result, the belt is shifted radially [shifted inwardly] inward relative to the corresponding [moulding] molding profiles of the known [tyre] tire (fig. 3) of same structure and size. The magnitude of the [Said] diametrical reduction corresponds to the [greater] expansion to which the known [tyre is submitted] tire experiences on passing from the [moulding] molding condition to the inflation condition when mounted on the rim. [

]This particular belt [conformation of the tyre] configuration, in accordance with the invention [enables], overcomes the drawback of [a quick] localized wear [of the known tyre to be overcome] as displayed by prior art tires.

Actually, on passing from the deflated-[tyre] tire condition (or rest condition) to the use condition, the inflating pressure expands the whole belt radially outwardly[; in]. In particular, the greater expansion of the central belt portion 16, caused by the presence of groove 11, gives rise to a reversal of curvature of said central portion and a shifting of points A and B to points A' and B' on the predetermined inflation profile (chain line) [thus bringing]. Thus, the external tread profile changes from configuration P_1 shown in Fig. 2 to configuration P_2 shown in the

same figure and corresponds to the tire profile under use conditions. In this situation, [corresponding to the tyre use profile.

At this point] the inflating pressure cannot cause further localized [expansions in] expansion of the tread[,] at the groove area, [in that] because the belt expansion [that cannot overcome given values bound to its structure,] has been completely exhausted in bringing the profile of its central portion from a concave rest configuration[,] of lower diameter to the convex use configuration[,] of greater diameter.

Therefore, [at the]in the tire of the present invention, near groove 11 there are no longer tread areas subjected to greater expansion and therefore greater specific pressure against the ground than the remaining side portions [and therefore subjected to a greater specific pressure against the ground, and consequently the]. Consequently tread abrasion takes place evenly over the whole surface of the ground-contacting area[, which will bring about overcoming of the drawback found in known tyres and consisting in a quick]. This tire successfully overcomes the drawbacks of rapid and continuous localized [wearing.] wear characteristic of known tires.

[The tyre] The tire belt in accordance with the invention must be manufactured in a manner adapted to [take said] provide the variable curvature configuration which varies between two opposite, concave and convex, positions[: in]. In particular, the belt features taken as a whole are capable of [enabling,] storing, during the [tyre moulding, storage of] tire molding, elastic energy due to the imposed deformation of the central belt portion[, which]. As a result, energy is released during the deformation in the opposite direction imposed by the inflating pressure, thereby facilitating the curvature reversal and enabling the [tyre] tire belt to easily achieve its work disposition.

In a convenient embodiment represented by a prototype [tyre] tire, size 195/60 R 15 made by the Applicant, the [tyre] tire comprises a belt structure provided with two radially superposed layers

of a rubberized fabric reinforced with metallic cords of formation 10[, that is consisting]. This fabric consists of 1 strand of 3 steel wires[,] of a diameter preferably included between 0.20 and 0.32 mm, in this case 0.28 mm[, the]. The cords in the fabric [having] have a thickness included between 70 and 110 wires/dm, in this case 85 wires/dm, and are preferably oriented at an angle included between 20° and 30°[,] measured crown-wise with respect to the equatorial plane of the [tyre] tire, in this case 25°[, and]. Also, the cords are directed symmetrically with the cords of the adjacent layer.

Disposed at a position radially external to [that of said pair of] the two layers [there] is a third layer, and preferably two further layers radially superposed, of textile cords[, conveniently]. These cords are ~~made of nylon of 1400/1 dTtex and are directed circumferentially to the~~ [tyre; this] tire. This third layer is advantageously made up of one or more cords helically wound in one or more layers about [said] the layers of crossed metallic cords.

[In connection with said dimensional and structural values of]At the end of the molding step, the reinforcements and belt [respectively,] have the following values for the radii of curvature relating to the three belt portions diagrammatically shown in Fig. 4 [can be reached at the end of the moulding step]: - radii of curvature r_1 and r_2 of the belt side portions are included between 120 and 500 mm, - distance between [centres; of] centers; radii r_1 and r_2, measured in axial section, [parallely] parallel to the rotation axis of the [tyre,] tire, are preferably included between 10% and 30% of the belt width, - radius of curvature r_3 of the belt portion 16 is preferably included between 20 and 150 mm.

In accordance with a preferred alternative embodiment of the invention, the [tyre] tire comprises tread stiffening means disposed in the groove 11[, the main function of which is that of]. This tread stiffening means continuously [modifying] modifies the curvature reversal of the third belt portion from concave to convex during the [tyre] tire inflation. This stiffening means offers a

resistance to curvature reversal thereby avoiding the occurrence of movements by jerks that could give rise to [tearings] tearing of the [tyre] tire in the underlying cushion, [that is that] or the portion of reduced thickness included between the groove bottom and the belt. To perform [said] this function, there are several different solutions for reinforcing the groove [I I may be provided, of which] 11. Of these solutions, those resulting from particular geometries of the tread band within the groove itself are preferred.

In a preferential solution shown in fig. 5, the groove 11 comprises a circumferentially continuous rib 17, extending in cantilevered fashion from the groove bottom, preferably arranged symmetrically to the [centre] center line plane of said groove.

Preferably rib 17 is of a shape and thickness adapted to avoid formation of a hinge at the groove bottom[, that is]. Such a hinge would provide a concentration point for [all efforts and deformations] deformation connected with the bending movement reversing the belt curvature, [which] and it would bring about the well known disadvantages.

The rib 17 can be made of an elastomeric material, preferably of the same blend as the tread band or, alternatively, of a different blend[, which] that may [be] optionally be filled with inert reinforcing fillers of the type usually used in [tyres, such as for example] tires. Examples of these inert reinforcing fillers include short aramide fibres of fibril structure, commercially known as aramide pulp, or magnetic powders [so as to use said rib]that allow the rib to be used as a medium for recording codes and various information of technical or commercial kind, relating to the [tyre] tire.

The rib 17 comprises a head portion of flat or even wedge-shaped or curvilinear configuration, preferably connected to the groove bottom by curvilinear flanks in the form of an arc of a circle [for example]. Preferably, the two portions [too] of the groove bottom separated from each other by the rib are connected to rectilinear flanks defining the groove by means of curvilinear

connections. Advantageously, the rib head 17a can be made of a [coloured] colored blend, optionally of the fluorescent type, for different purposes such as aesthetic, commercial (such as a trademark) or safety purposes[, for signalling reaching of the aquaplaning danger and/or]. In a safety oriented role, the colored rib can indicate the maximum admissible wear limit for the tread[. It is clear that this] and thereby indicate when aquaplaning danger is present. This solution can be applied to the [tyre] tire independently of the presence of a belt in conformity with the invention.

In the Applicant's above mentioned prototype [tyre] tire, the groove in fig. 5 has a [maximurn] maximum width "a" of 20 mm (i.e. corresponding to 12% of the tread width, and preferably included between 10% and 18% of said width), a depth "p" of 8.5 mm and preferably included between 7 and 9.5 mm, a rib height "h" from the groove bottom of 3 [nun] mm and preferably included between 1.5 and 4 mm, in which the p/h ratio between the depth of said groove and height of said rib has a value preferably included between 1.75 and 6.5[;]. The groove also has a width ["1]"l" of the rib head of 4.6 [nun] mm and preferably included between 3 and 8 mm[; preferably]. Also, the arcs [of cercles] for connection between the groove walls and rib walls preferably have a radius ["k]"K" of 2.5 mm and preferably at least [as large as] 2 mm.

The underlying cushion thickness, that is the minimum thickness of the [compound] material interposed between the groove bottom and the facing surface of the radially outermost belt layer is [of] 2 mm, and preferably included between 1 and 3.5 mm.

As an alternative solution to the above, the stiffening means for the groove could comprise a series of ribs, all of same shape or [not] of different shape, departing in cantilevered fashion from the bottom[, for]. For example, this series of ribs can be disposed either in a single circumferential line [spaced apart from each other,] or in several circumferential lines in side by side relationship and optionally staggered relative to each other.

Fig. 6 shows a specific embodiment of the invention in a high-performance [tyre] tire provided with a pattern of the directional type[: clearly the]. The present invention advantageously applies to any pattern type, not only a directional type but also a symmetric or asymmetric type, [with] having blocks or ribs[,]. The invention is especially applicable, although not exclusively, when provided with large circumferentially-directed grooves[, the]. The specific usefulness of [which] the invention is that of eliminating an early wear concentrated on the areas close to said groove edges.

In [the connection it is to note that in] the present description, reference has been always made to a groove 11 extending in register with the equatorial [(centre](center line) plane of the [tyre] tire so that the [centre] center of curvature of the central concave portion 16 of the belt structure is shown lying in said plane. However said groove can extend also along one or more circumferential planes that do non coincide with the equatorial plane of the [tyre: it is clear that in] tire. In such a case, the [centres] centers of curvature of the three different portions too (14, 15, 16) will undergo corresponding [shiftings] shifting in the axial direction.

The drawing in Fig. 6 is a convenient elaboration of the tread pattern in a symmetric version, disclosed in the Applicant's patent application MI 93 A 00 1119 of May 31, 1993[(to which please refer for more detailed information)], now European Patent EP 0 627 332 B1, for the purpose of [specializing use of same for] specialized use in marked sports utilizations.

The pattern comprises, in combination with the central groove 11 preferably provided with rib 17, a plurality of transverse grooves 24 extending axially on both sides of the equatorial plane and in mirror image relationship with respect to said plane, between the central groove 11 and the corresponding tread end[,]. These transverse grooves are greatly inclined in the longitudinal direction close to the central groove[,] and are directed almost axially on the side tread portions. [Said] The transverse grooves, in combination with a plurality of longitudinal grooves 23

extending circumferentially to the [tyre] tire and transverse slits 25, define a plurality of blocks 18 distributed in circumferential parallel rows 19, 20, 21, 22.

Preferably, each of [said] the rows comprises at least as many blocks as the number of blocks present in the row disposed consecutively thereto in side by side relation towards the equatorial plane of the tread. It is apparent from the foregoing that [also] the symmetric pattern of said patent application can be associated in a particularly advantageous fashion with the belt structure in accordance with the invention[: in the tyre]. In conjunction with the tire of the present invention, these patterns achieve a high resistance to the aquaplaning effect [together with a strong], increase traction power, [excellent behavioural. qualities,] provide a low abrasion capability, [minimum] reduce rolling resistance, and [high quietness on] reduce noise while running.

One can intuitively easily understand how an accelerated wear of the central portion of said patterns, particularly promoted by the tapering configuration of the block edges in the central rows would make the corresponding [tyre] tire seriously deficient in relation to the intended type of use, in addition to involving an economic loss resulting from the reduced lifetime of same. [It is apparent from the foregoing that for accomplishment of] To accomplish the invention, [moulding] molding is carried out according to a particular profile of the belt structure [the geometrical size of which must be calculated in advance, for]. For the purpose of achieving the desired [effect.] effects, the geometrical size of the profile must be calculated in advance.

In accordance with the invention, [said moulding] the molding profile for the [tyre] tire is imposed by assigning a specific profile in cross-section to the vulcanization [mould] mold surface. The vulcanization [mould too is] mold, taken as a whole, is of a known and traditional type [and therefore those details that are considered as inessential for comprehension of]. Therefore, the specific details of the vulcanization mold that are not essential in comprehending the present invention [are herein omitted. It will be sufficient to remember that the mould] have

been omitted. As stated earlier, the mold comprises two axially opposite cheeks corresponding to the [tyre] tire sidewalls, and an intermediate annular portion disposed between the two cheeks [and]. For molding of the tread pattern, the annular portion is provided on its radially inner surface[,] with a matrix having a plurality of ribs projecting in a raised configuration from a bottom surface [for moulding of the tread pattern].

Shown in Fig. 7 is the cross section of this [mould, the] mold. The use of a sector [mould] mold of the centripetal type [being assumed, obviously not in a limiting sense.] is assumed but is not meant to limit the type of mold of the present invention.

[There is therefore] There is the problem of establishing the amount of radial deviation between the traditional matrix profile and the profile to be assigned to the matrix of a [mould] mold in accordance with the invention to achieve [said] the desired belt profile. [

]The process of the invention is therefore carried into effect as follows.

As already said, the [tyre] tire structure is a structure known per se; it is herein pointed out that the [tyre] tire is also assembled in the traditional way following the known methods and with the usual apparatuses of the state of the art, until a green [tyre] tire ready for vulcanization is obtained.

Thus, a known [tyre] tire is prepared in the stated usual manner[, which tyre]. The tire is subsequently vulcanized, to provide the final tread pattern, in a service [mould the] mold having geometrical sizes [of which have been] that are calculated in the traditional way[, provided with the final tread pattern. From the preceding explanation it is therefore]. It is apparent that the final [tyre] tire profile under use conditions also depends on the overall features of the tread pattern thereof.

The profile 26 of the radially inner surface of this [mould] mold is denoted by a solid line in Fig. 7. In the same Fig. 7, [identified by 27 are some] ribs designed to form cavities and grooves in the tread pattern [: in] are identified as element 27. In addition, [also] highlighted by a dotted line is the profile 28 of the [mould] mold as modified in accordance with the invention [and by a chain]. Chain line 29 indicates the profile of the surface tangent to the rib ridges according to profile 28. [

]The determination of the inner profile for the new [mould] mold takes place as follows.

The known [tyre] tire vulcanized in a service [mould] mold is mounted to the respective rim and inflated to the exercise pressure.

Detection of the radially external profile (P_5 in Fig. 3) of the tread band is carried out from one end to the other, thereby determining the actual [tyre] tire expansion (or shrinkage, if present), that is the punctual deviation value of this profile, point by point, along its axial extension, from the known theoretical profile (P_3 in Fig. 3) resulting from the design.

Then [said] the deviation values are used for construction of the final [mould for tyre] tire vulcanization mold; in other words, these values are negatively reproduced on the corresponding points of the matrix surface (bottom surface) of the service [mould] mold, thereby determining the new radially internal profile 28 of the bottom surface of the corresponding final vulcanization [mould] mold.

[Practically] Generally, it is [generally] sufficient to [detect value] measure R, [of] the radius in the known [tyre] tire inflated to its use pressure, at the equatorial plane[, determine]. Next, the difference between this radius and radius R_0 of the same known [tyre] tire under non-operating conditions[, i.e. rest conditions, reproduce] is determined. The value S of the R_1 -R_0 difference is reproduced on the radially inner surface of the service [mould] mold at the equatorial plane [and

join]. Next, this point at the equatorial plane is joined (while keeping unchanged the geometry and sizes of the ribs encountered along the axial extension of the profile) to two other points (C, D), one on each side of the equatorial plane, at which deviation between the two profiles [is zero, for drawing] marked by R_1 and R_0 is zero. From these points, the new radially inner profile of the final [mould] mold is drawn. [

]At this point the new inner profile of the [mould] mold is completely defined.
Preferably [the process will make use of the radius detection] at at least three distinct points, one central point at the equatorial plane and two side ones, for example at the groove edges or disposed axially externally of said edges[, and more]. More preferentially, the process will make use of the radius measurement at five points, two of which are located close to the tread-ends.

[Conveniently, the] The process [will be] is put into practice by carrying out vulcanization in the service [mould] mold and inspecting a plurality of known [tyres] tires, so as to construct a table of values from which the average final value to be used will be drawn. In this manner the consequences of accidental errors and fortuitous disturbances that could alter the results of a single detection can be eliminated. The process in accordance with the invention will be preferably followed for preparing the final [moulds] molds for each different [tyre] tire size.

The new profile of the matrix bottom surface consists of two distinct and axially opposite concave side portions in respect of the equatorial plane of the [mould, each of them being] mold. Each of the portions is defined by a radius of its own and a [centre] center of curvature of its own, in which the respective radii r'_1 and r'_2 are preferably identical with each other[, whereas the]. The profile of the surface tangent to the rib ridges according to the new profile has a central portion, included between said side portions, which is radially inwardly convex. Thus, the concavity of [which] this portion faces [said] the bottom surface, identified by a radius r'_3 relative to the envelope arc of the rib designed to form the groove [I I] 11 in the tread band.

In the described example, the following values of the radii of curvature r'_1, r'_2, r'_3 in the matrix have been found: $r'_1 = r'_2$ in the range between 150 mm and 300 mm, r'_3 in the range between 20 mm and 150 mm.

Thus the final [moulds] molds can be built up and the production of [tyres] tires in accordance with the invention making use of these [moulds] molds can be carried out.

During the [tyre moulding] tire molding and vulcanization step, carried out[, as] in a known[,] way by blowing fluid under pressure into the [tyre] tire held inside the vulcanization [mould] mold, the greater penetration of the inner [mould] mold profile due to the value of lowering $R_1 - R_0$ relative to the [mould] mold of the known art gives rise to a compression on the corresponding belt portion [which]. This compression results in formation of a hollow or concave portion 16, visible in Figs. 2 and 4, the depth of which measured along its [centre] center line plane is substantially the same as [lowering] the distance S assigned to the inner profile of the known [mould] mold, in accordance with the described process.

At the end of the cycle, [pulled out of the mould is] a vulcanized [tyre] tire having the [mould] mold configuration delimited by profile 28 of Fig. 7 in turn corresponding to profile P_1 of Fig. 2 (except for the rib 17 not shown in Fig. 2) is pulled out of the mold. The tire[.

The tyre] keeps its [moulding] molding shape until use, and takes it again when it is deflated.

[In case of use, after] After mounting the [tyre] tire to the corresponding rim, air under pressure is inflated into the closed space between the rim and the [tyre] tire to provide the use condition. During inflation, the air pressure [urges] pushes against the whole belt surface and gradually reverses the convexity of the central belt portion[, this]. This action [being] is facilitated by the return of the previously-stored elastic energy [due to deformation] of the deformed metal wires in the belt.

[Therefore the] The ranges of variability of the specific physical and geometrical parameters cited in the preceding description of a particular embodiment of the [tyre] tire in accordance with the invention represent critical value ranges for an optimal achievement of the advantages resulting from the invention.

The work configuration of the belt is a stable configuration (Fig. 4) identified by a curvature continuously convex towards the outside over its whole extension.

The tread profile follows the stable belt disposition and is identified by convex curvatures as well over its whole extension[: preferably, it]. Preferably, the tread profile has two radii of curvature rb_1[,] and rb_2, identical with each other on the side portions of the band, and a third radius of curvature rb_3 the [centre] center of which is along the equatorial plane [and the]. The value of [which] the radius of curvature rb_3 is preferably [is] greater than that of the side portions, with a ratio value $rb_3/rb_1 = rb_3/rb_2$ included between 1 and 5[; this]. This profile is the profile P_2 in Fig. 2 which is [well] greatly different from [that] the profile of known tires (P_3 in Fig. 3) [obtained in known tyres,] after inflation of the [tyre] tire mounted on the respective rim[, and in particular it]. In particular, the profile of the tire profile of the present invention is a substantially flat profile at the area surrounding the groove 11[, capable of ensuring]. In contrast to prior art tires, this profile ensures a uniform specific pressure over the whole ground-contacting area of the [tyre] tire. [

]Consequently, the [tyre] tire of the present invention overcomes the problems of localized and early wear of the tread, [encountered in the] which is prevalent among known [tyres] tires.

It will be finally recognized that the foregoing description is for purposes of illustration only and therefore a person skilled in the art, after understanding the invention as above disclosed, will be

able to carry out modifications, variations and replacements of the variables associated with the present invention in order to meet specific and contingent requirements for application of same.

ABSTRACT

A mold for tire vulcanization that includes axially opposite sidewalls and a tread band molded with a raised pattern formed with at least one circumferential groove. The mold has a pair of axially opposite cheeks corresponding to the sidewalls of the tire and a matrix interposed between the cheeks, which corresponds to the tread band. The matrix has a plurality of ribs projecting in a raised configuration from a bottom surface. The sectional profile of the bottom surface comprises two distinct concave side portions and the sectional profile of the surface tangent to the ridge of the ribs in the area included between the side portions has a convexity directed radially inwardly.

[ABSTRACT

A tyre (1) comprising a tread band (10) provided with at least one wide groove (11) extending circumferentially and a reinforcing belt (6) which, in the deflated tyre, on its radially external surface shows an axial configuration made up of three portions, a first and a second portion (14, 15) of convex shape, disposed lateraly of the equatorial plane of the tyre, and a third portion (16) of concave shape, disposed at an intermediate position between the two side portions to form a hollow in register with said circumferential groove. The maximum depth value of said hollow (16) is such that, when the tyre is inflated to its use pressure, the belt is stabilized to its final configuration comprising the three portions which are concave on their radially internal surfaces, and with an external tread profile in the predetermined final configuration substantially identified by two side portions at the sides of the central groove (11), which are of identical radii of curvature (rb1, rb2) and are connected to each other by a third portion the radius of curvature (rb3) of which is of greater value than that of the side portions.

Fig. 2.]